Update of CH_4 Retrieval

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PSGS

AIRS Science Meeting

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Topics of Today

Part I Validation of CH4 products in V5

Part II Retrieval problem (Caveat ?) associated with RTA

- **Tuning the CH4 peak channels by 2.5% in V5 has not a solid ground;**
- **CH4 amount has been used as a predictor in the computation of water vapor absorption;**
- **Improvement after re-selection of channels; Trapezoid functions; Damping; First-guess; Tuning**

Part III Science Application:

Comparison of AIRS CH4 w/ MODEL and Focus Study

- ✓ ***CH_4 plume over the Tibet plateau and its impact by Monsoon***
- ✓ ***Spatial and temporal variation of CH_4 in the high Northern Hemisphere and its relation with wetlands/permafrosts***

- **Summary**

I. CH4 Validation (V5)

Data sets used:

- **Aircraft** data from **NOAA Earth System Research Laboratory, Global Monitoring Division (ESRL/GMD)** (usually below 300 hpa)
- **Aircraft or balloon observation from ENVISAT CAL/VAL database**
- **Ground-based Fourier Transform Spectrometer** (FTIR) observation of total column amount of CH4

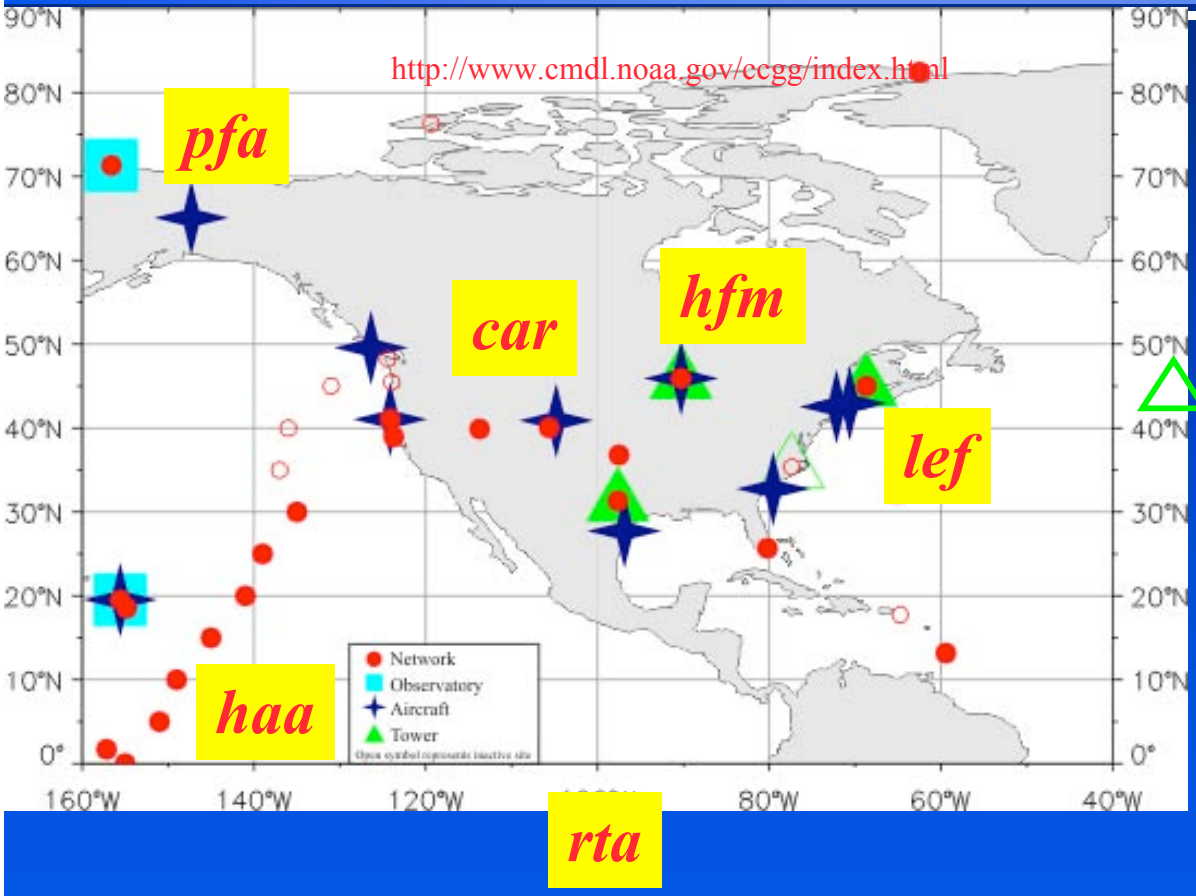
Publications:

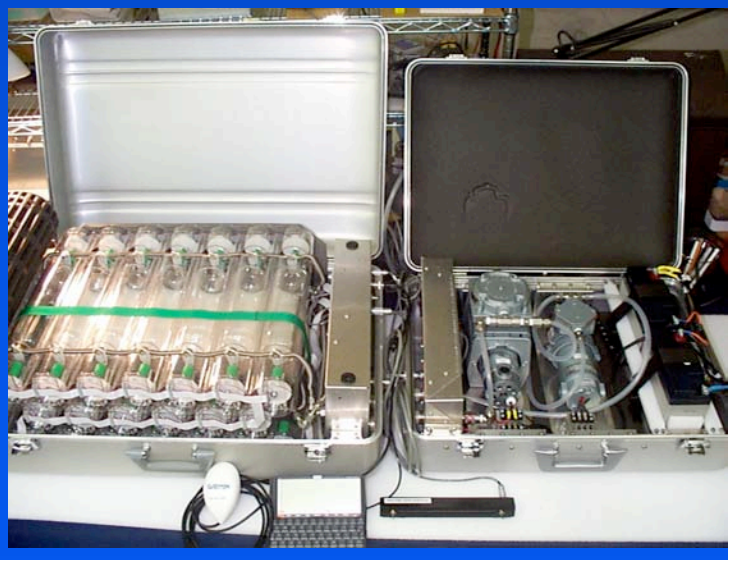
1. Xiong, X., C. D. Barnet, E. Maddy, C. Sweeney, X. Liu, L. Zhou, M. Goldberg, 2007, Characterization and Validation of Methane Products from the Atmospheric Infrared Sounder (AIRS), *J. Geophys. Res.* (revised).

2. Methane Plume over the Tibetan Plateau Observed from AIRS in the Summer and its Comparison with Model (submitted to GRL)

Validation (ESRL/GMD data)

NOAA ESRL/GMD North American Sampling Sites





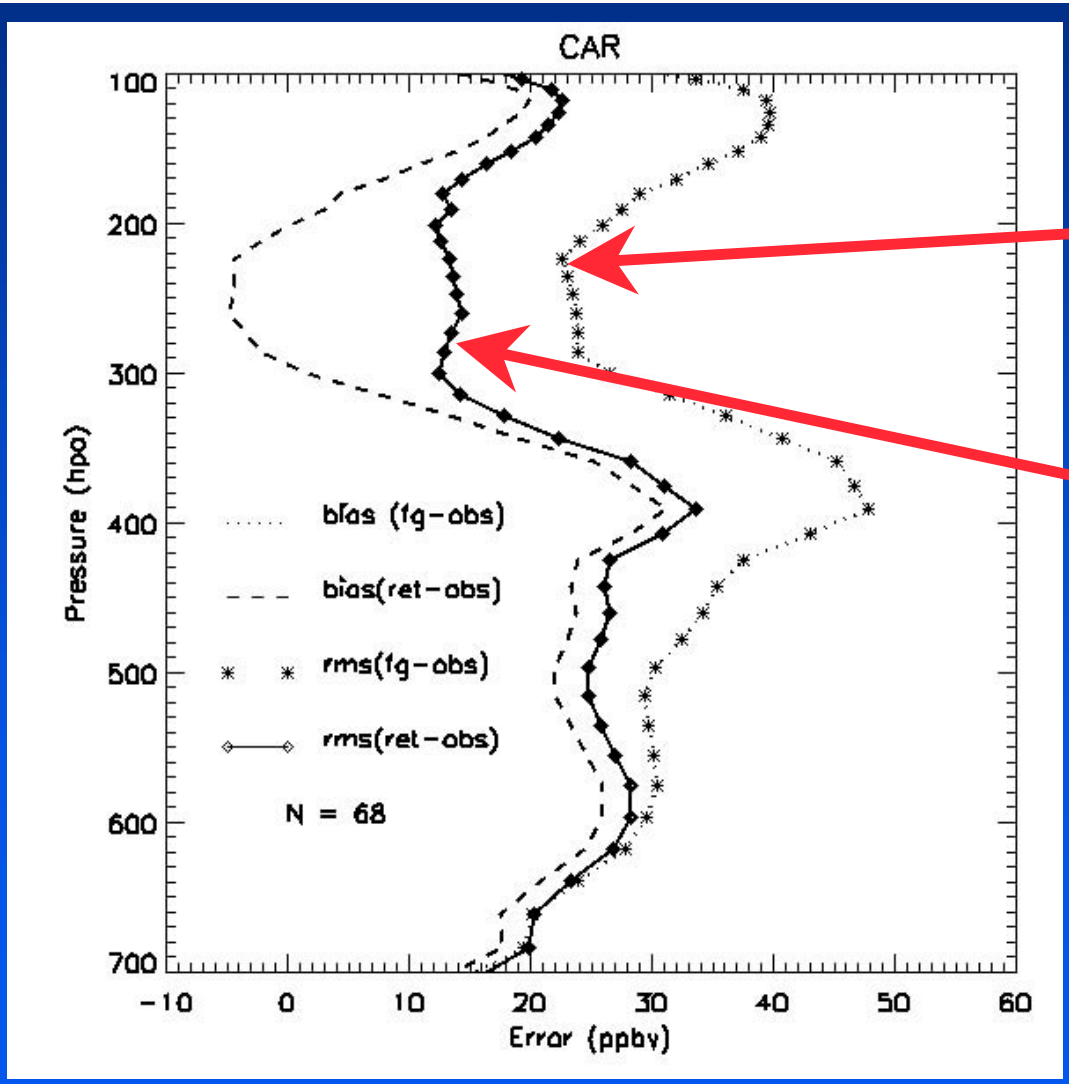
Aircraft

Tall Tower

Observatory

Network

Improvement in bias and rms errors of AIRS retrieval vs the first-guess at Colorado (CAR)

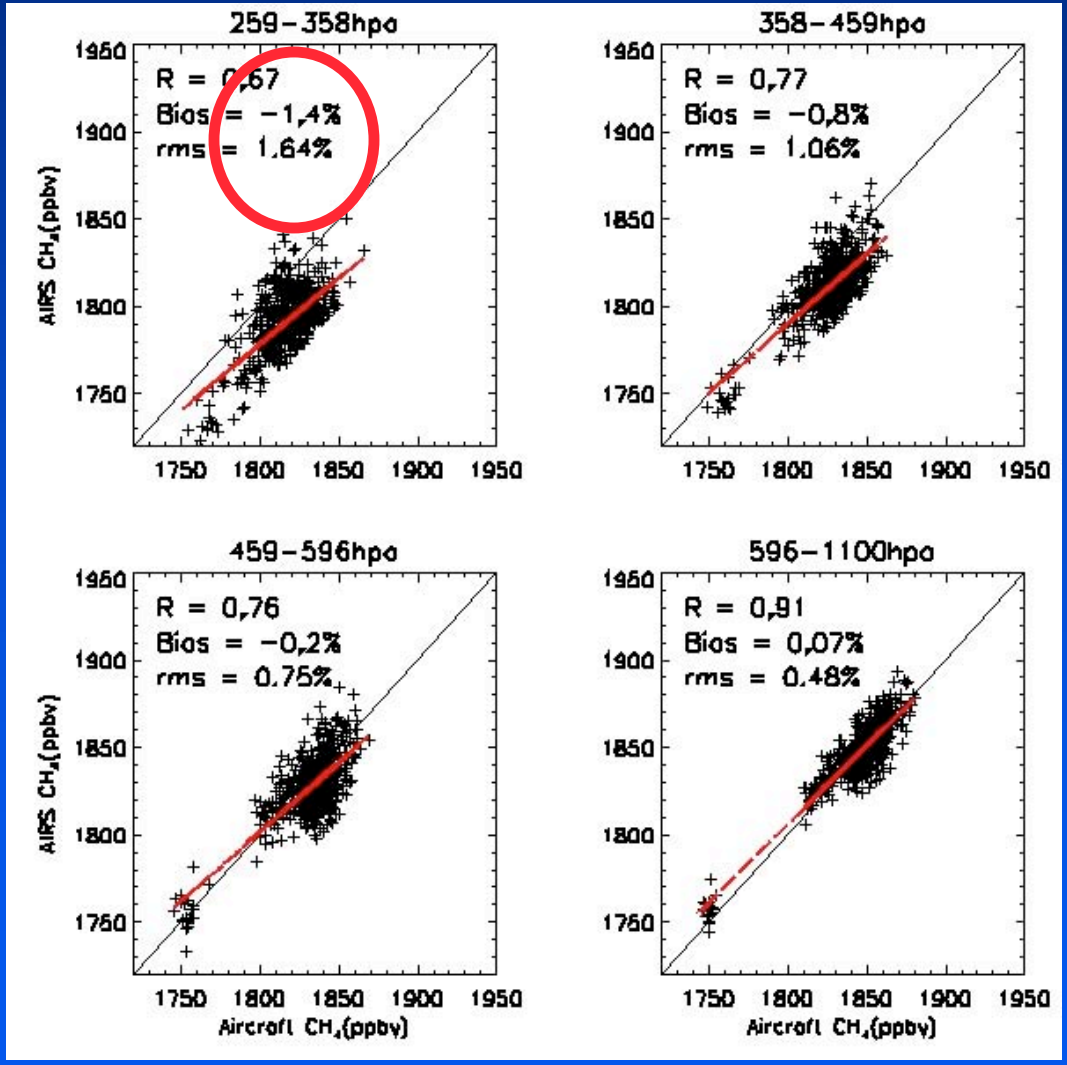


Firstguess-obs

AIRS-obs

Does AIRS retrieval do some work ?

AIRS CH_4 vs Aircraft Measurement (200, 300, 400, 650 mb --- V5)



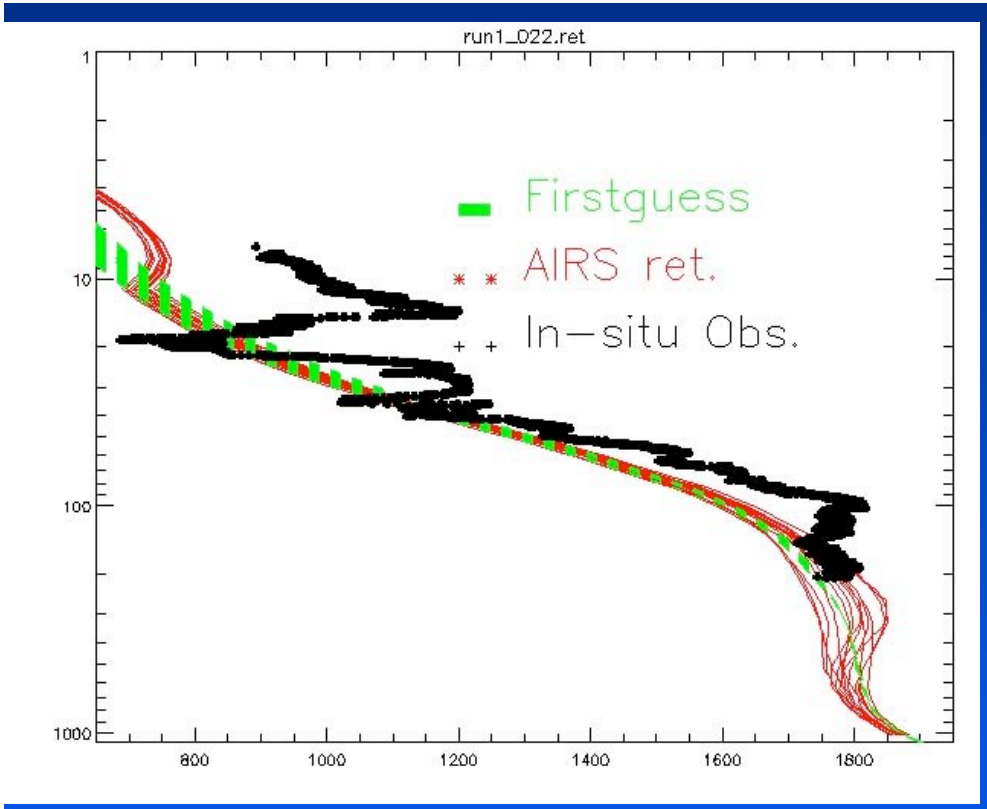
ESRL/GMD aircraft profiles are mostly below the most sensitive region of AIRS at 200-300 hpa.

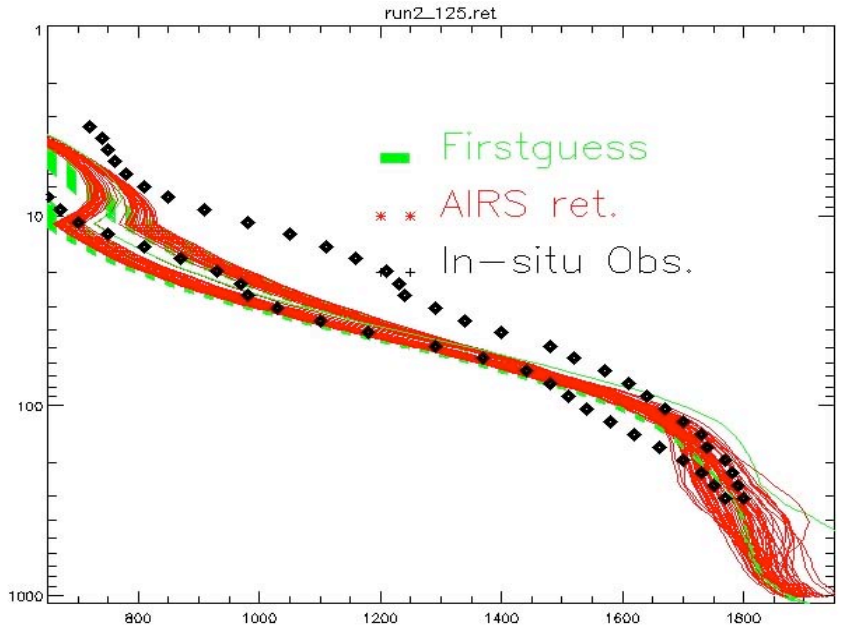
Collocation

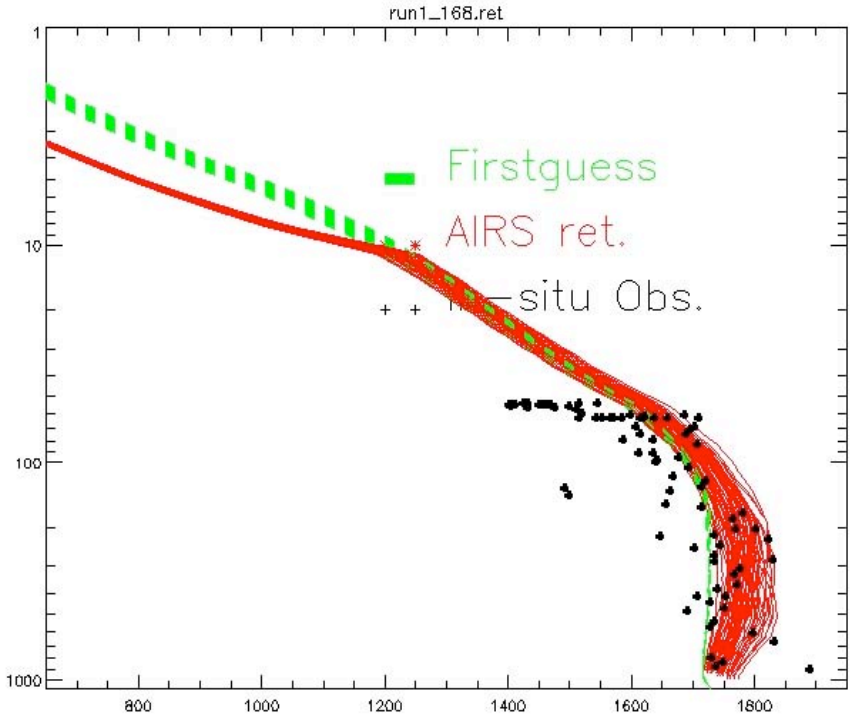
ΔR < 200 km

Δt < 24 hour

Profile Comparison



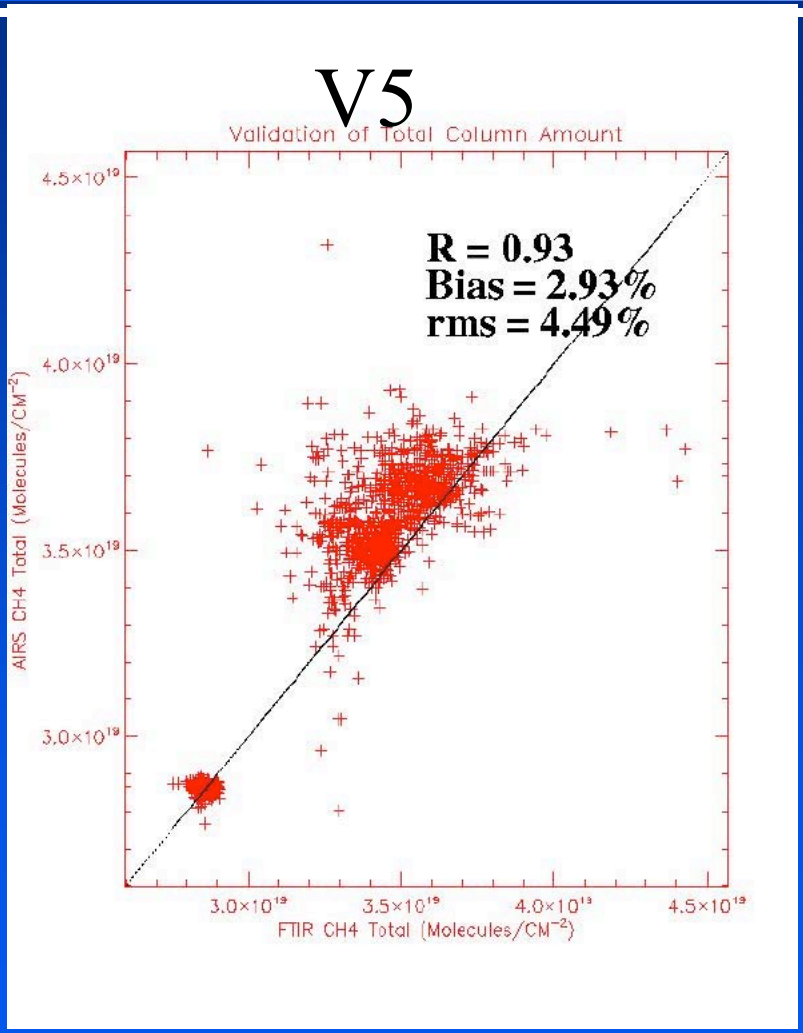


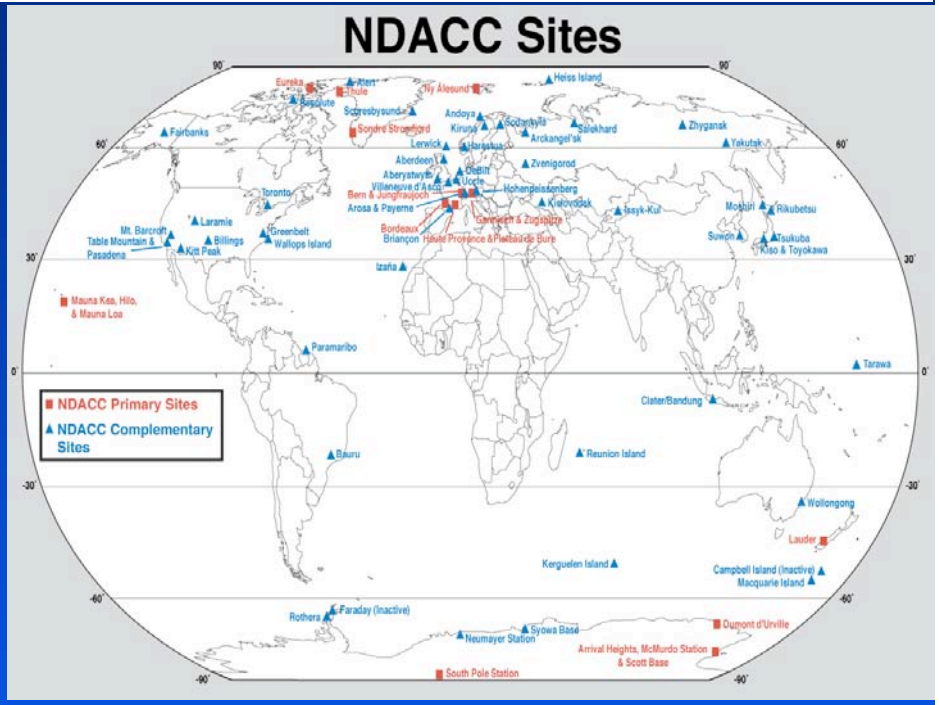


MIPAS (Michelson Interferometer for Passive Atmospheric Sounding) onboard the ENVISAT satellite. **In-situ data is from ENVISAT CAL/VAL Database.**

Total Column amount from FTIR

(Fourier Transform Spectrometer)

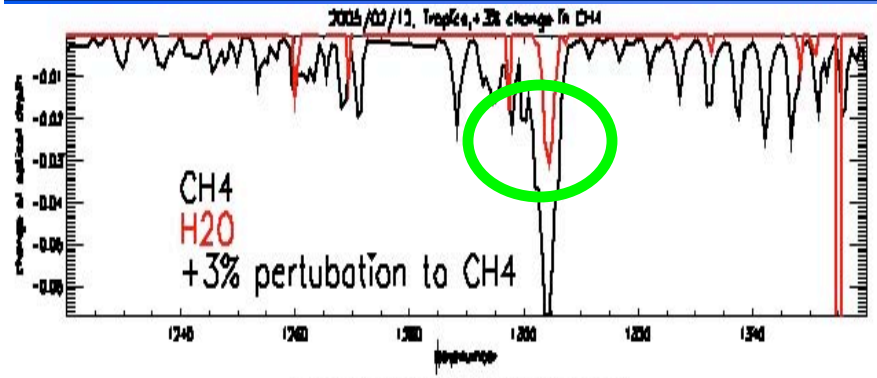


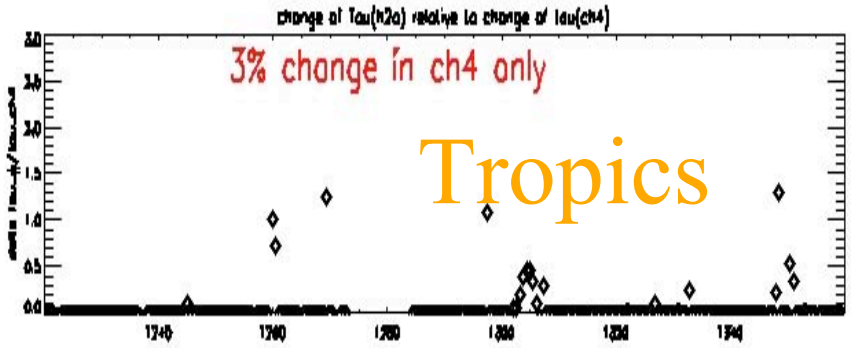


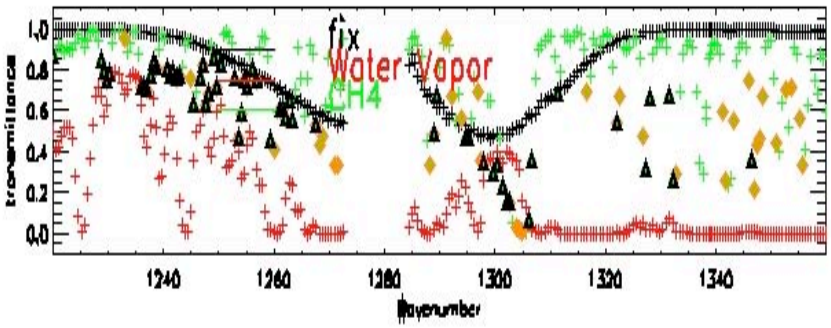
Network for the Detection of Atmospheric Composition Change (NDACC)

http://www.ndsc.ncep.noaa.gov/

II. RTA: CH4 amount as a predictor for the computation of water vapor absorption



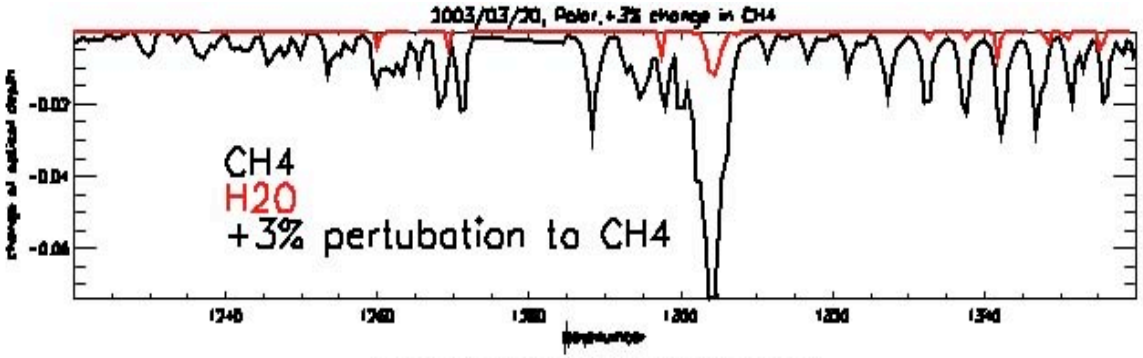


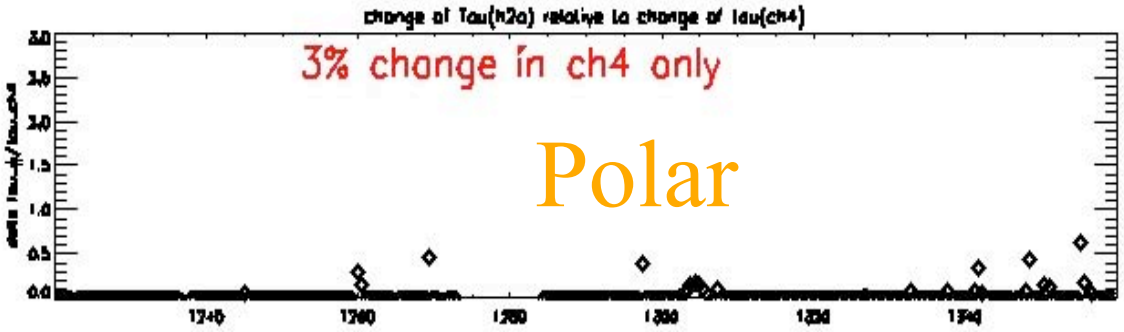


Perturbation to CH4 only also made significant change of H2O optical depth;

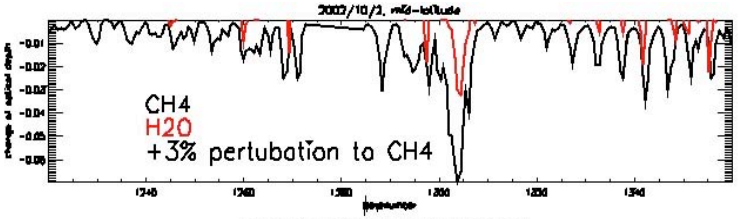
Is it real → needs to be examed using LBL model;

Recommendation: in order to use the CH4 peak channels, we may need to remove CH4 amount as a predictor, or use the reference amount as the predictor in the computation of H2O absorption

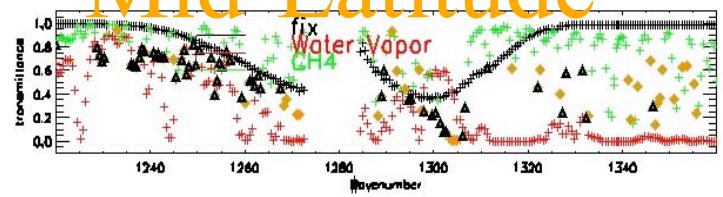


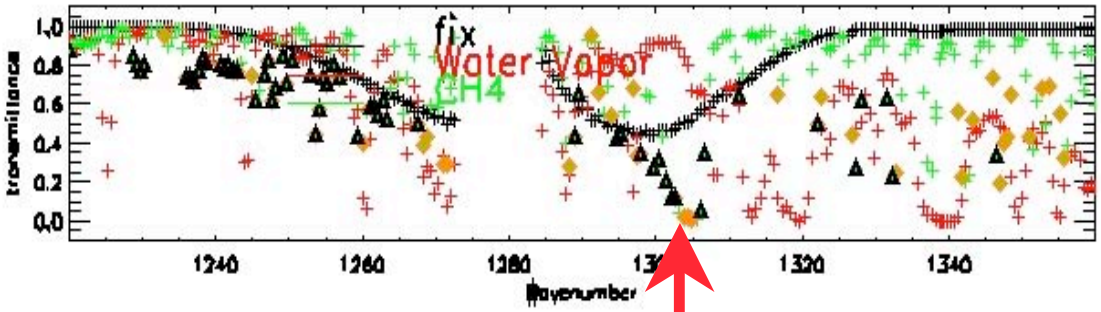


Polar



Mid-Latitude





We tried to re-selected channels by ignoring those channels Δh2o/Δch4>10%.

But we lost the most sensitive methane channels near 1305-1310. micron

Re-selection of channels and re-optimization to algorithm (V5+)

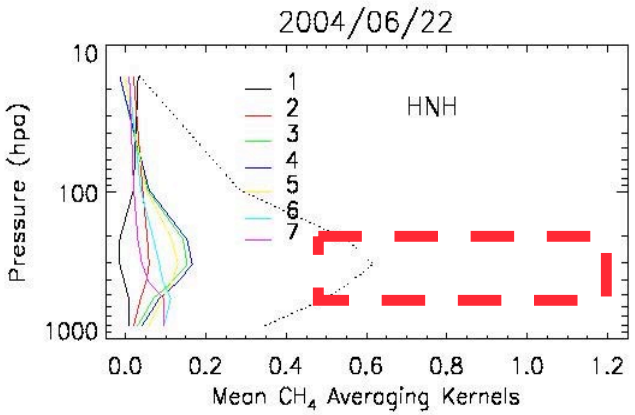
- Re-selection of channels : No channels in the peak CH4 channels
- Drapezoid functions : from 7 to 10
- Damping and First-guess : based on new data from ENVISAT CAL/VAL and model
- Tuning: based on new data from ENVISAT CAL/VAL

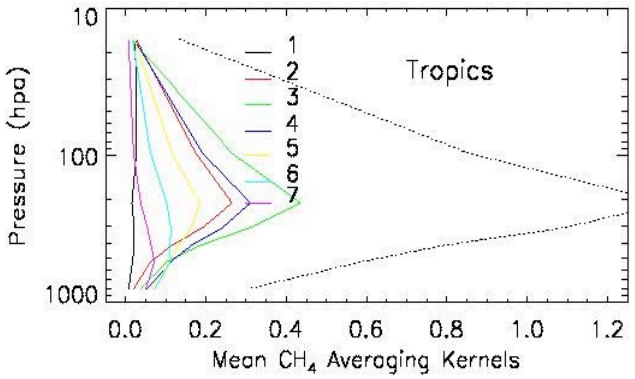
we called the version with these changes as V5+

- Improvements in the retrievals for "V5+" can be shown from the analysis of
  - Averaging kernels
  - Retrieval Uncertainty
  - Validation

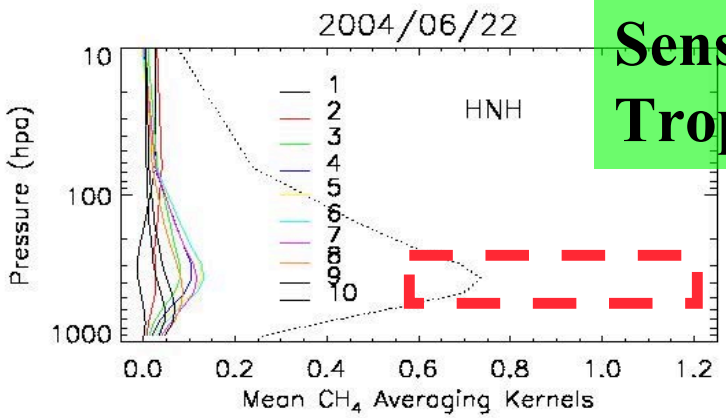
Change in Averaging Kernels

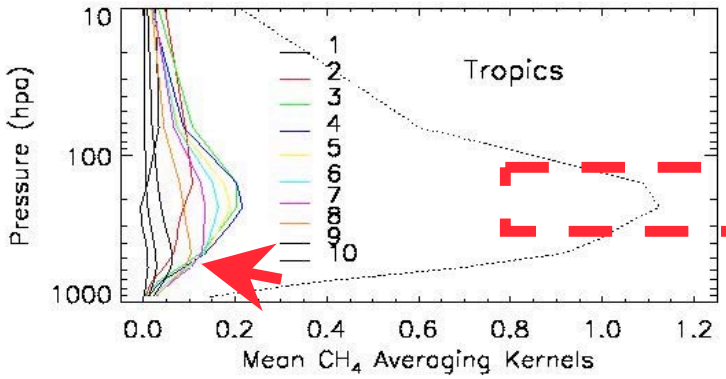
V5





V5+

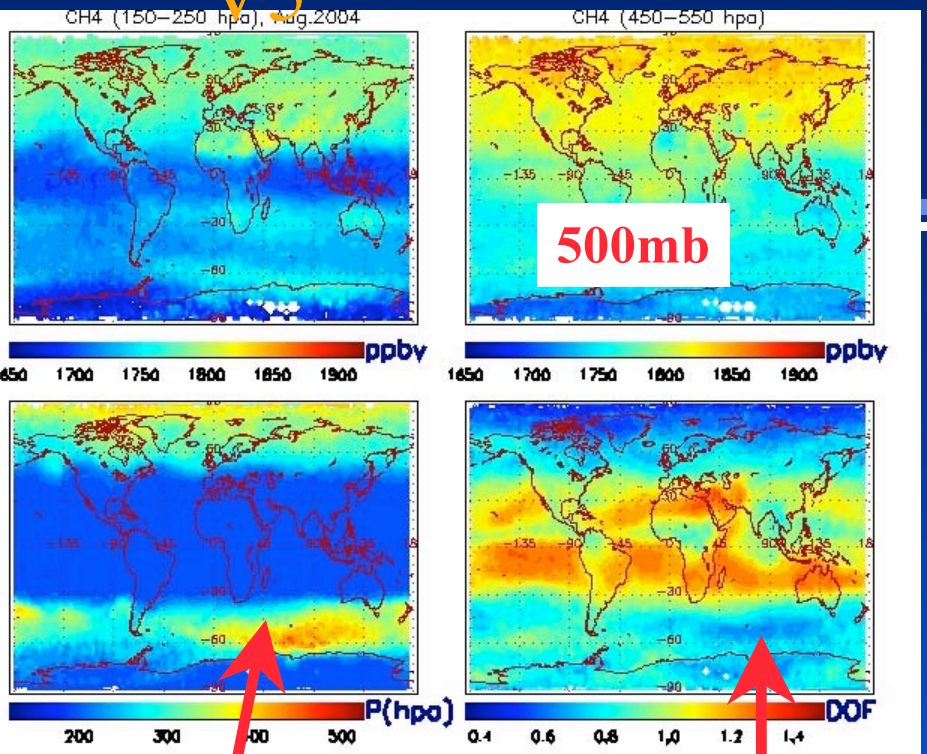




Tends to be more Sensitive to lower Troposphere

Change in information content

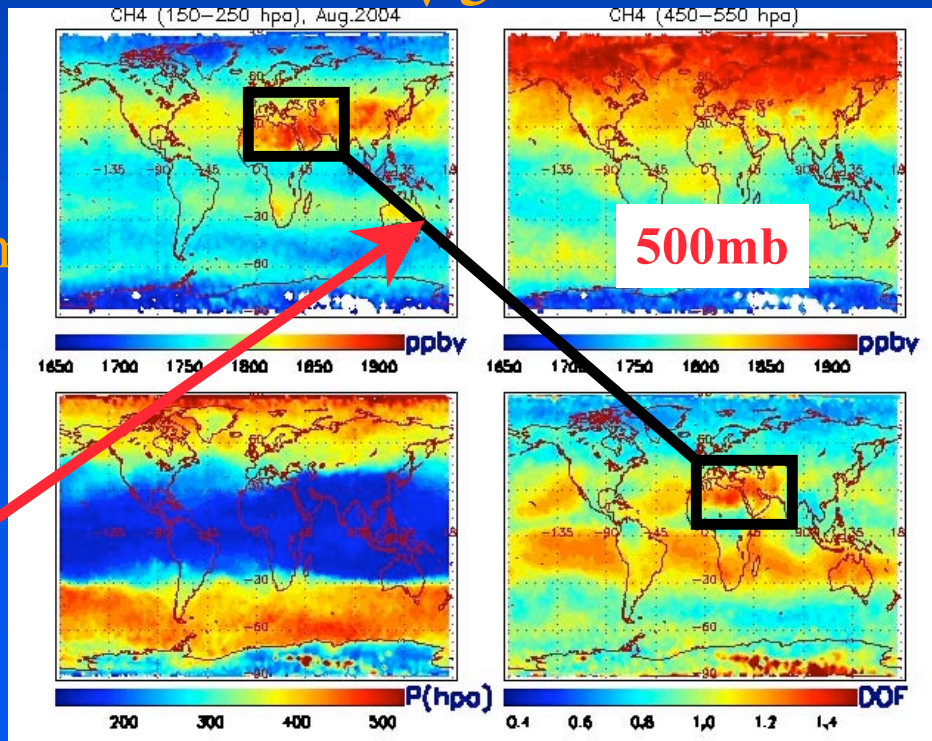
V5



Degree of Freedon

Pressure level of the maximum averaging kernel area

V5+

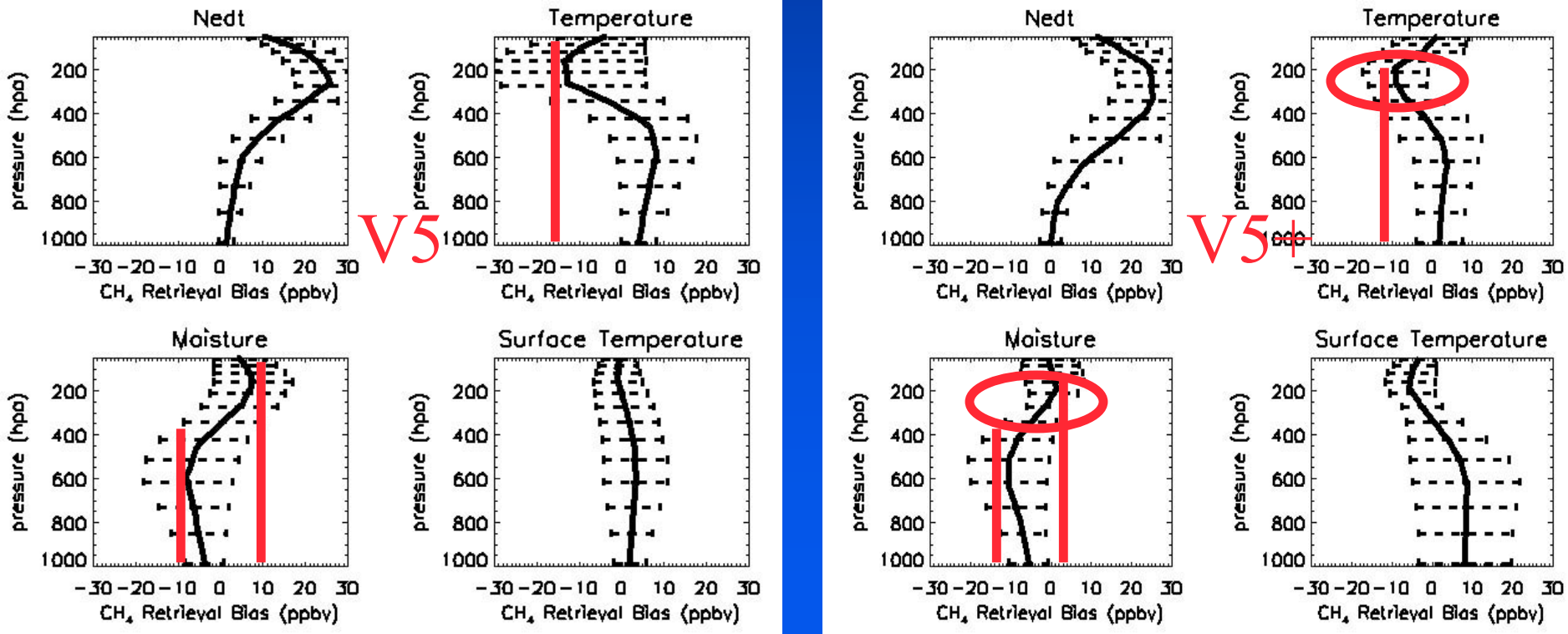


Large CH4 can be due to the increase of dofs

Retrieval Uncertainty in V5 and V5+

- Computed as the retrieval errors after adding the noise, bias in water vapor and temperature from Murty's validation to V4, and bias of Ts=2k
- Bias and RMS Errors are reduced in the V5+ except for surface temperature.

(here averaged using global data of two days)



More Improvements: Tuning

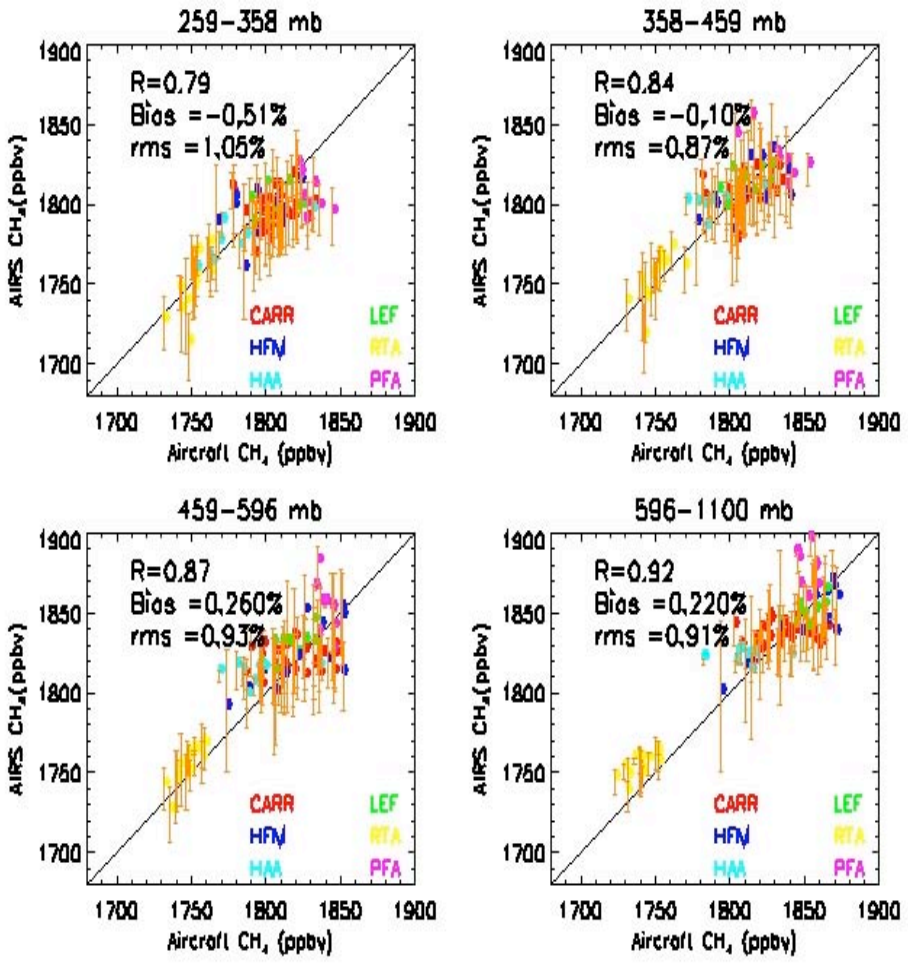
- In Version 5, we multiplied 2.5% to the coefficients to the peak CH4 channels.
- In V5+, we tried to tune using in-situ observation data – based on the radiance computation:

  R2(in-situ CH4, k *correction) ≈ R1(ret.ch4, k)

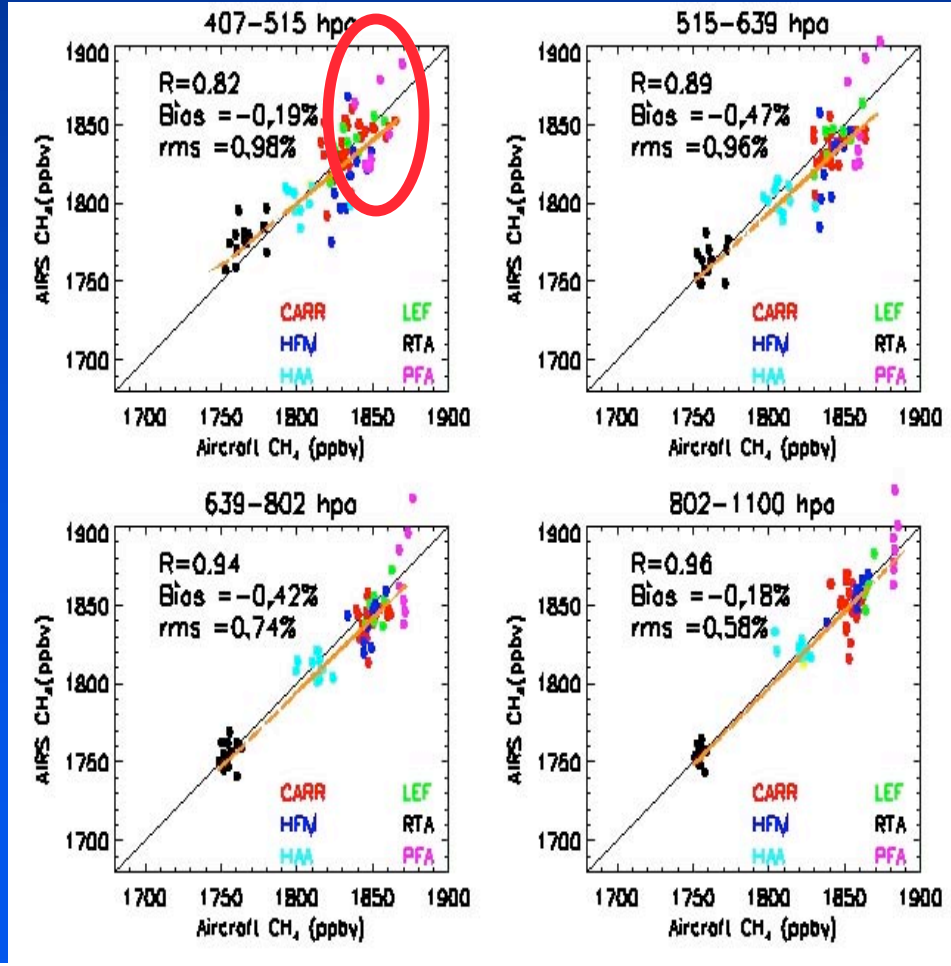
- It is in a range of 1-3% for CH4 channels

Comparison of V5 vs V5+

V5



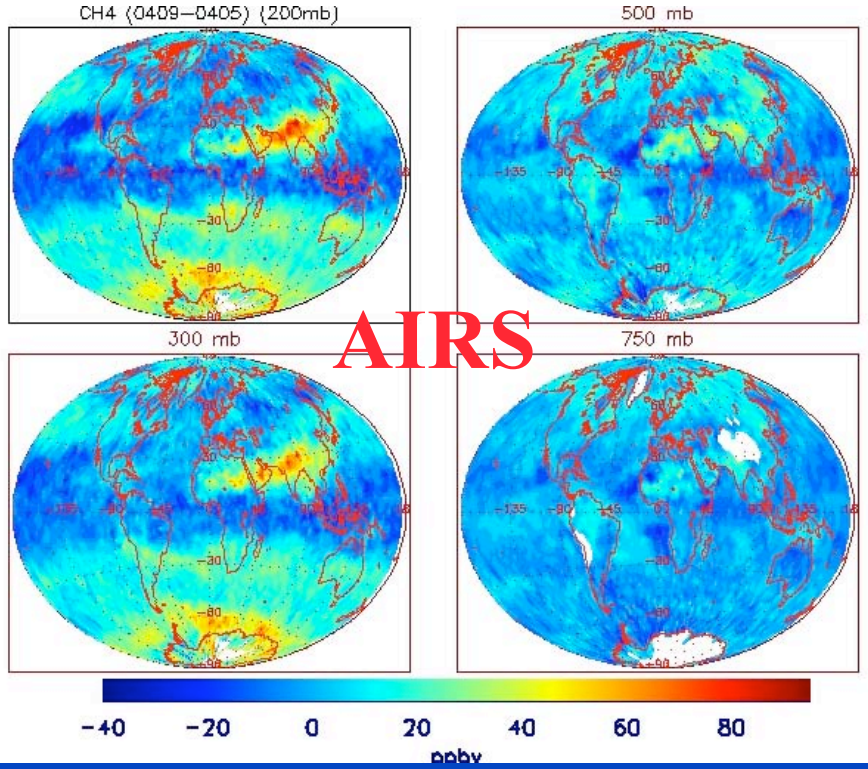
Re-select of channel and corresponding changes to functions and damping



III. Comparison of AIRS CH4 w/ MODEL and Focus Study

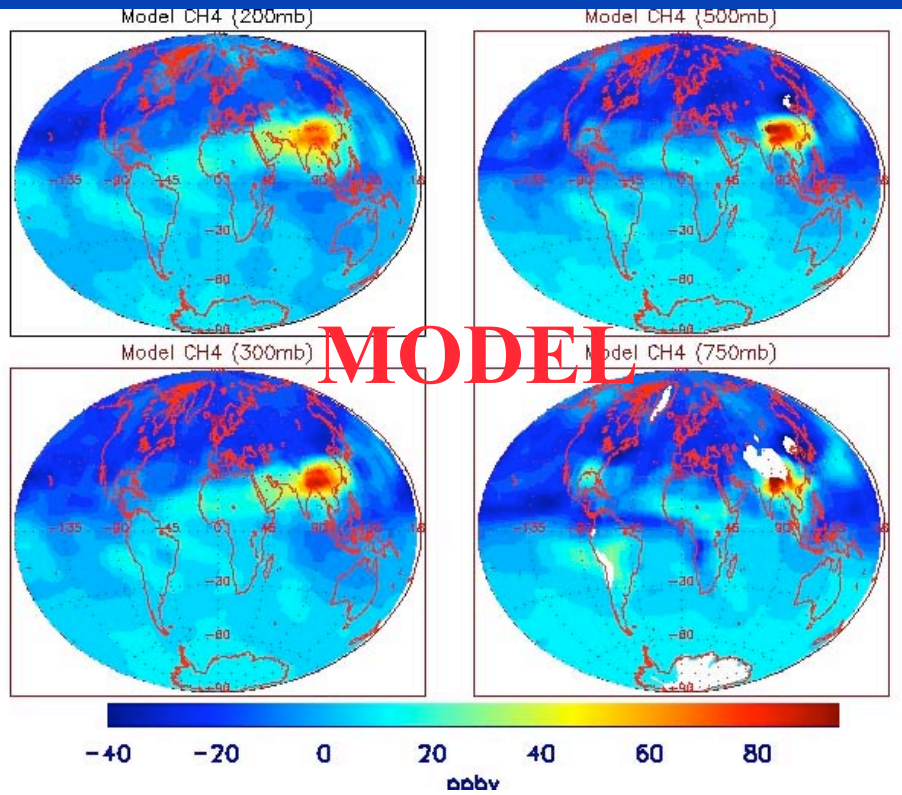
- ✓ Models : TM3, MOZART
- ✓ Observed CH_4 plume over the Tibet plateau and its impact by Monsoon
- ✓ Observed significant summer jump of CH_4 in the high northern hemisphere in regions mostly underlain by the wetlands → I*s it related with wetlands/permafrost ?*

--- Simple comparison with model w/o considering the averaging kernels



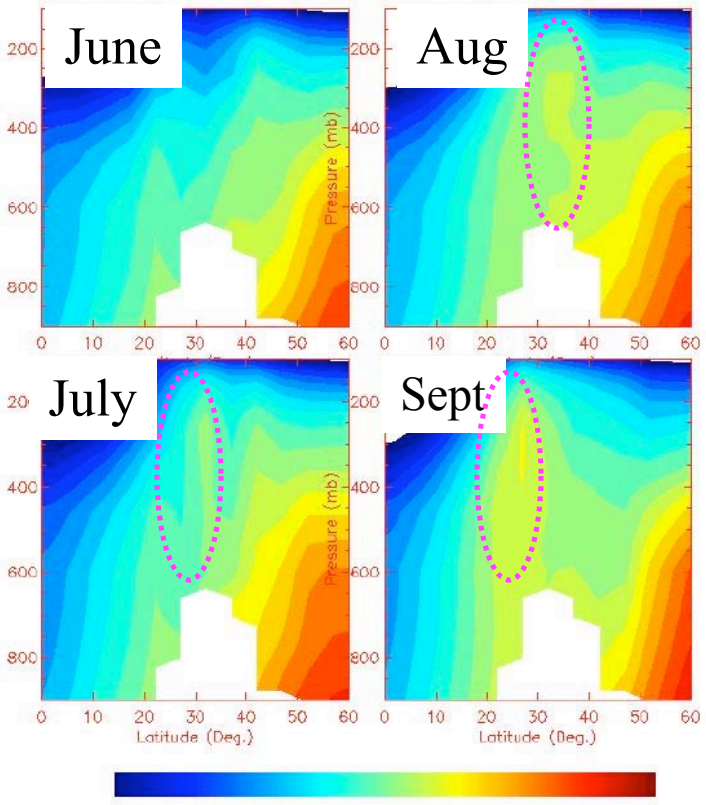
CH_4 Plume over the Tibetan Plateau from AIRS and MODEL (TM3)

Difference of CH4 before and after Asian Summer Monsoon (Sept. – May) at 200, 300, 400 and 750mb.

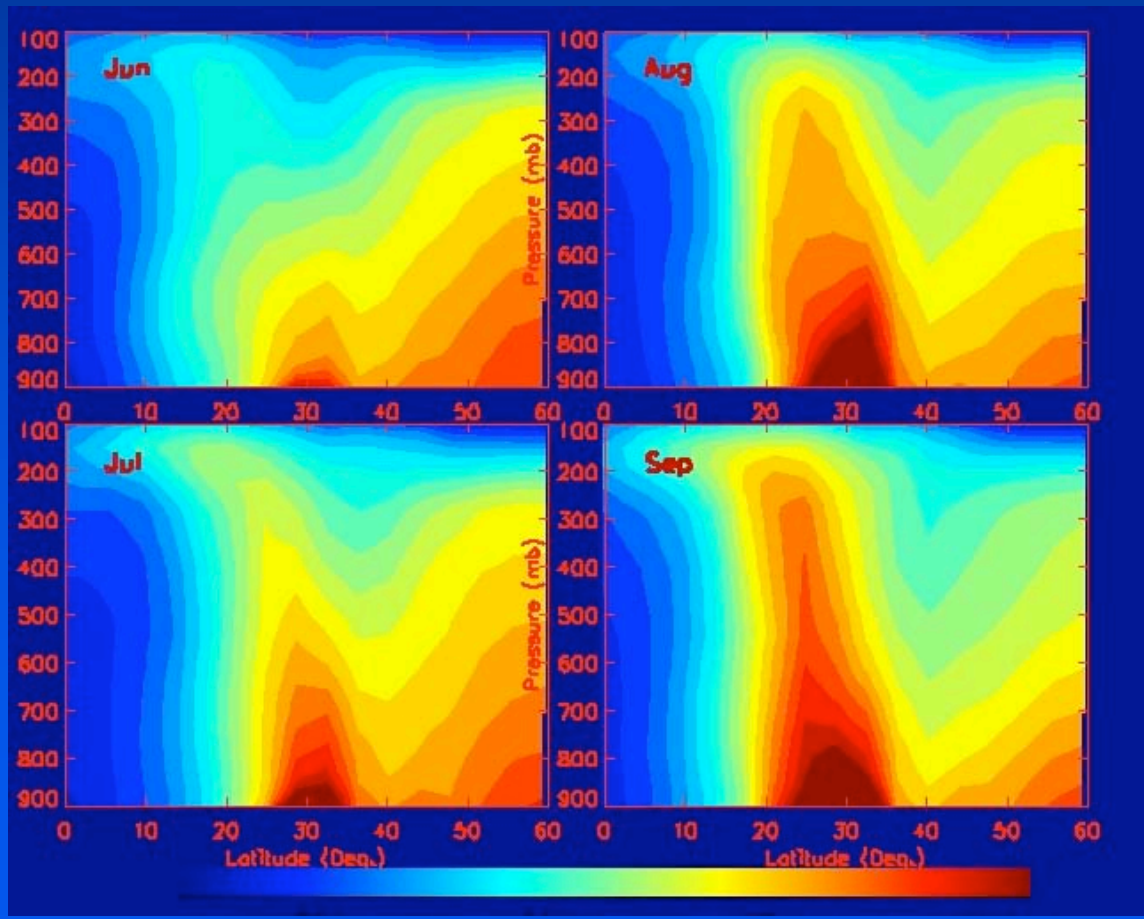


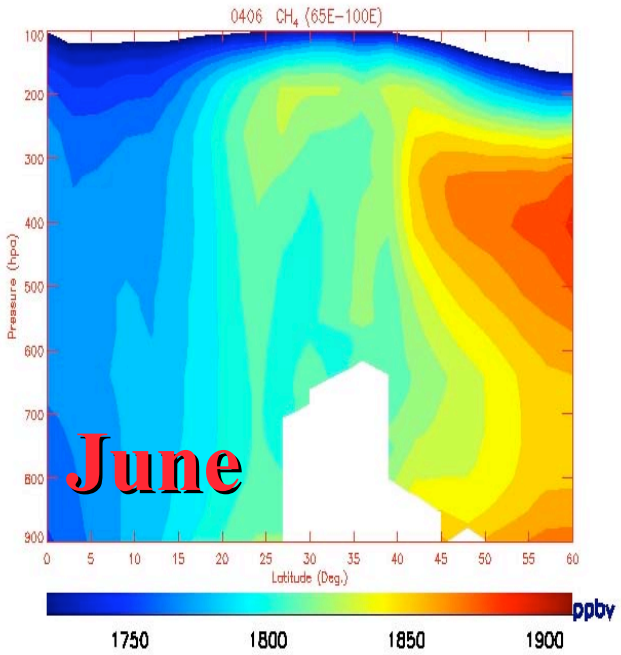
Zonal Cross Section & its Variation from June to Sept.

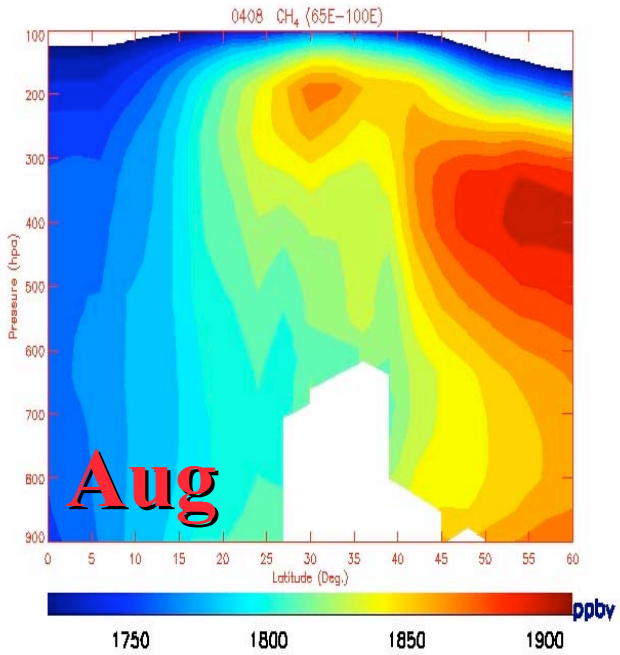
AIRS (v5)

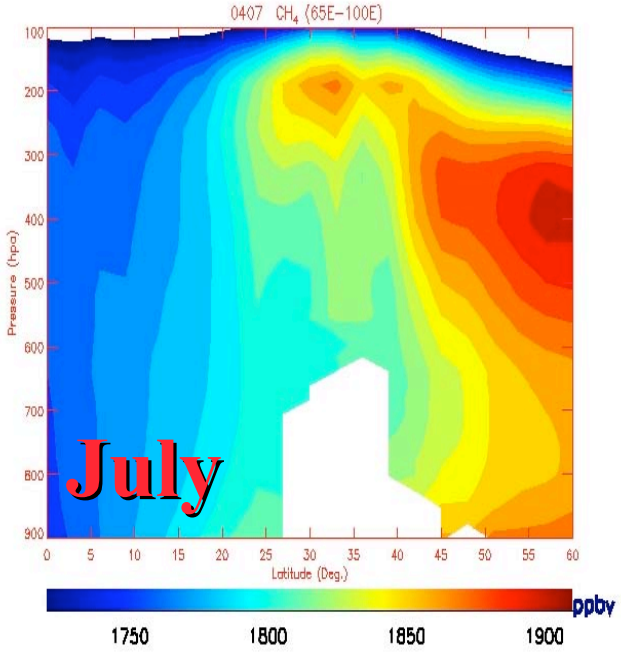


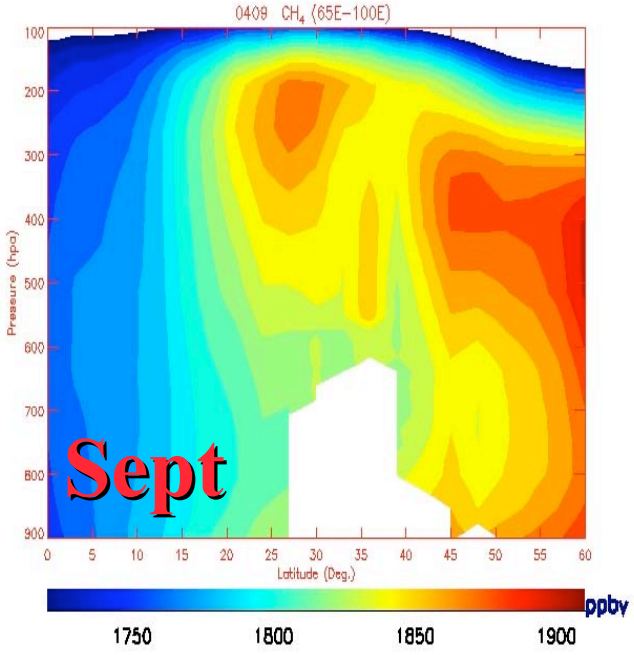
MODEL(TM3)





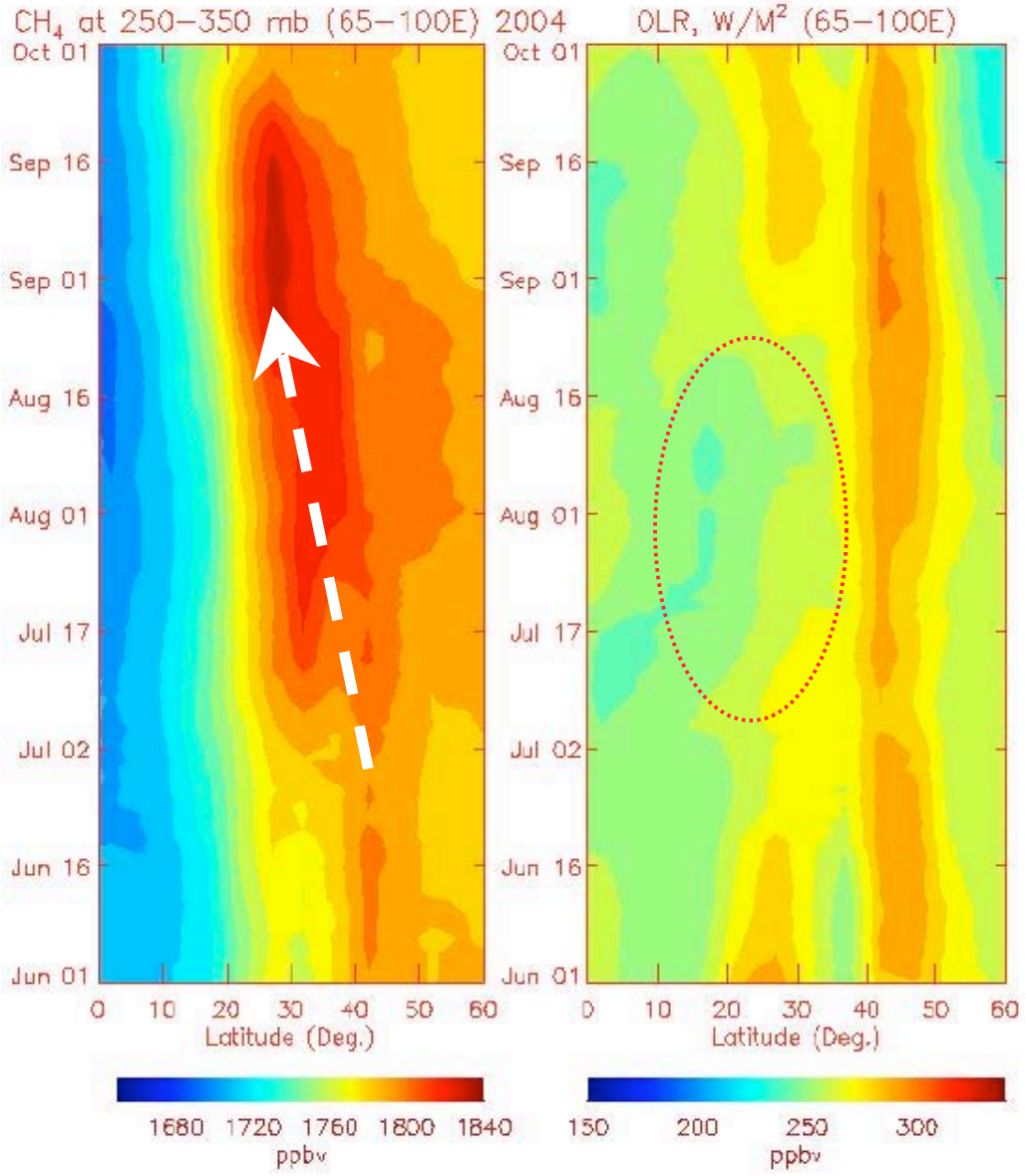






Zonal cross section from V5+ but no tuning

Increase of CH4 plume from June to Sept, but the pattern is a little different from V5 and model

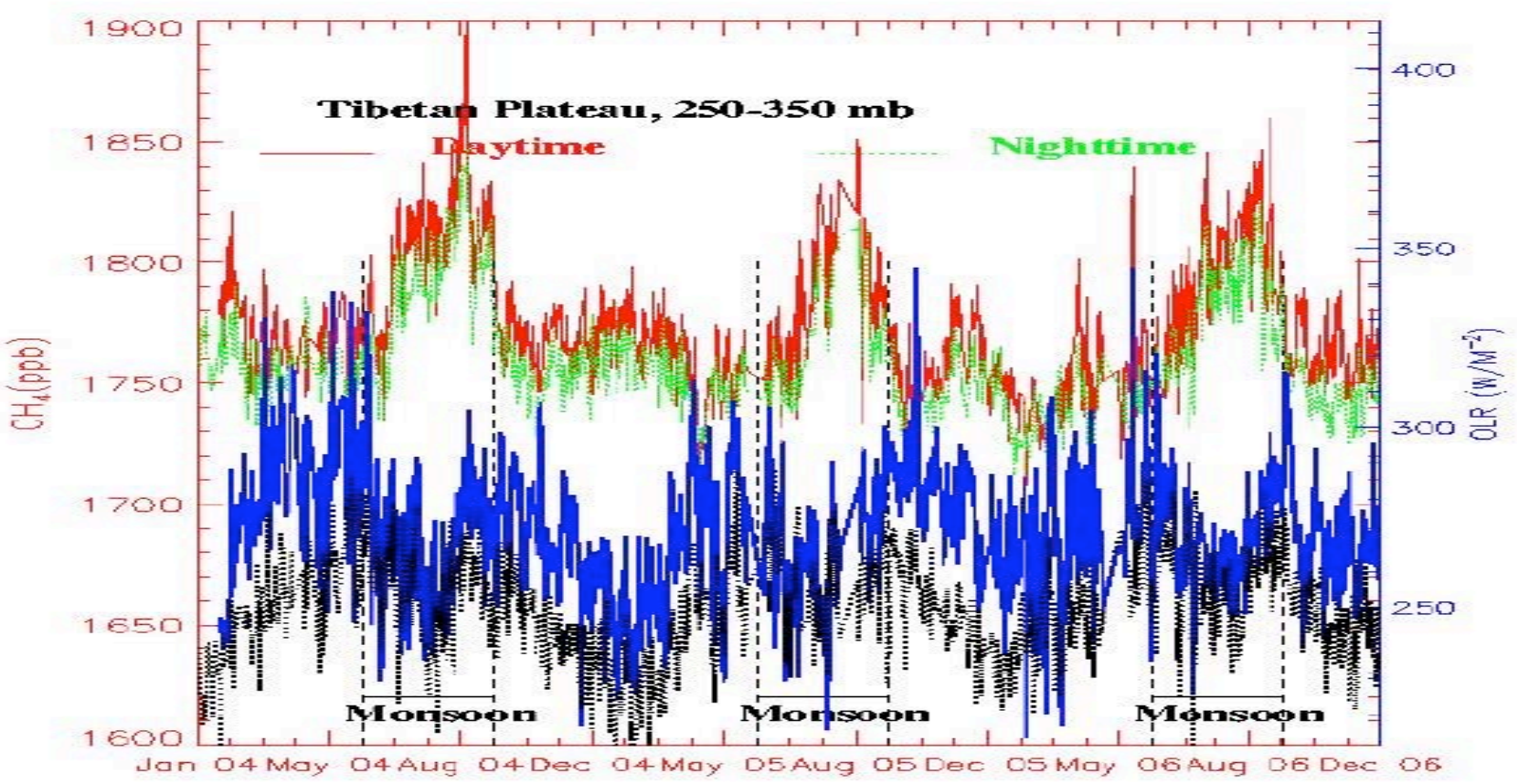


Seasonal Variation Of CH_4 over the Plateau and its relation with the deep convection during ASM characterized by OLR

Seasonal Variation of CH4 over the Plateau and its relation with the deep convection

CH4

OLR



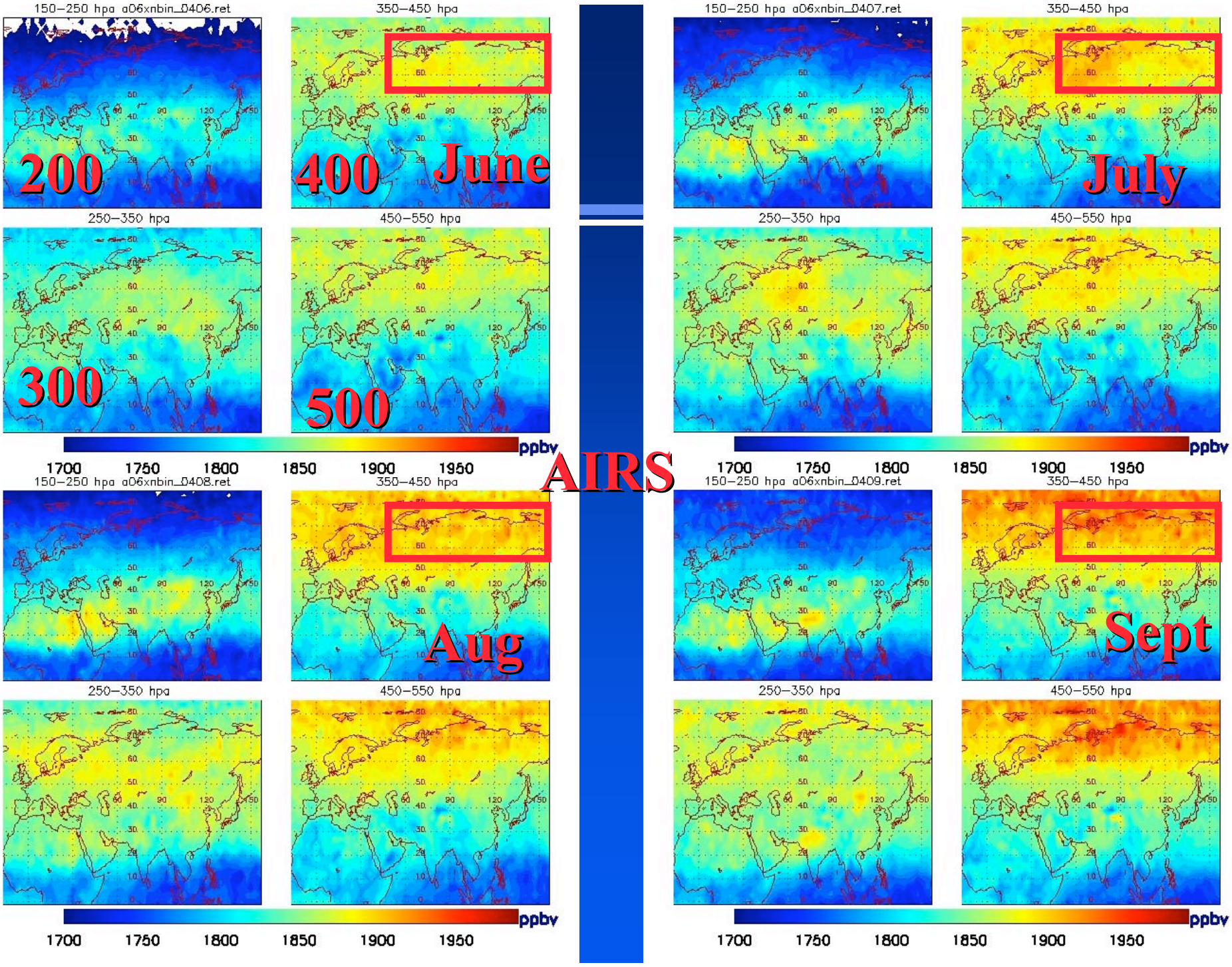
CH4 in HNH and Thawing of Permafrost

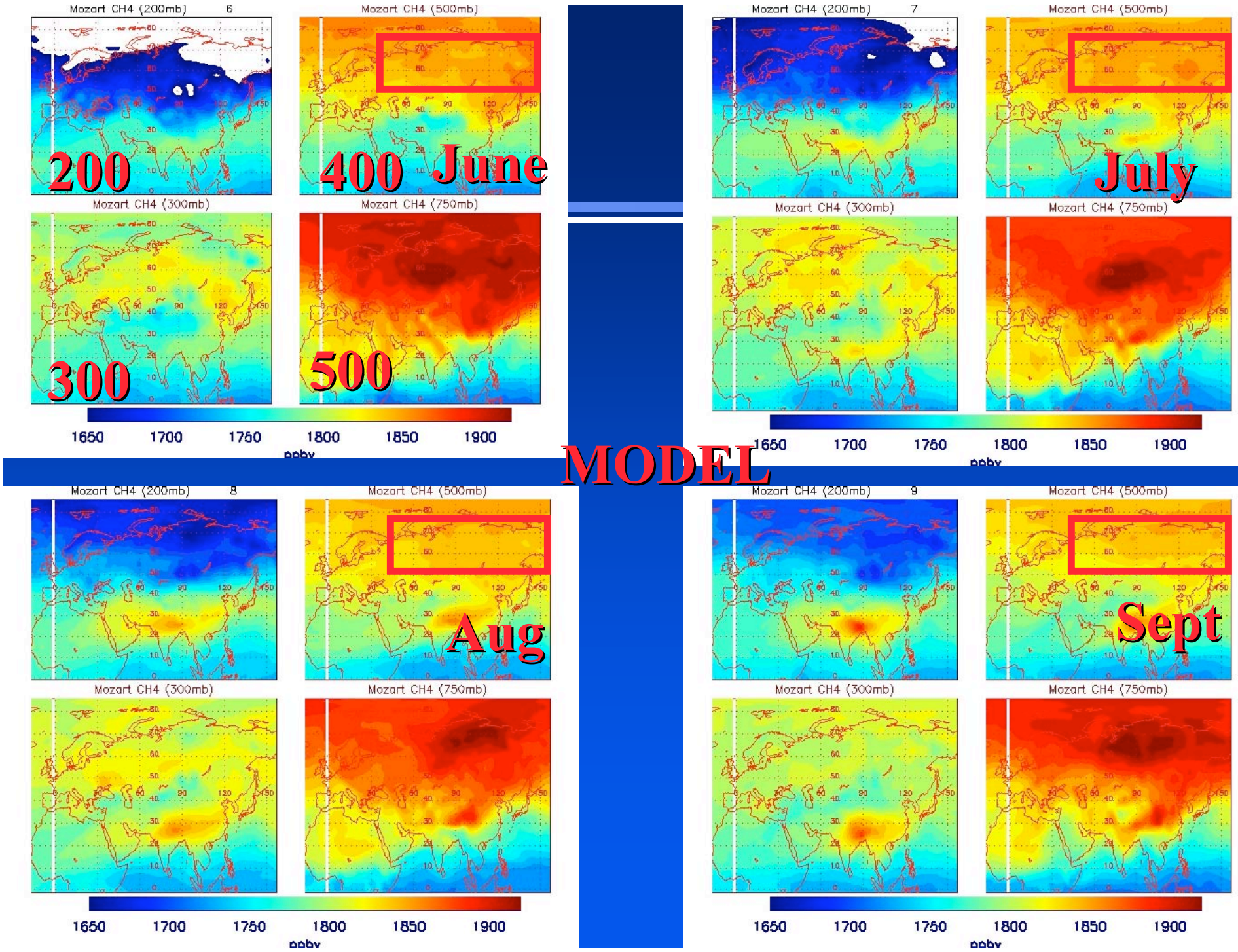
Speed-up of thawing of permafrost will increase of emission of CH4 (positive feedback to global warming).

AIRS observed significant increase of CH_4 from June to September in the high northern hemisphere in regions mostly underlain by the wetlands;

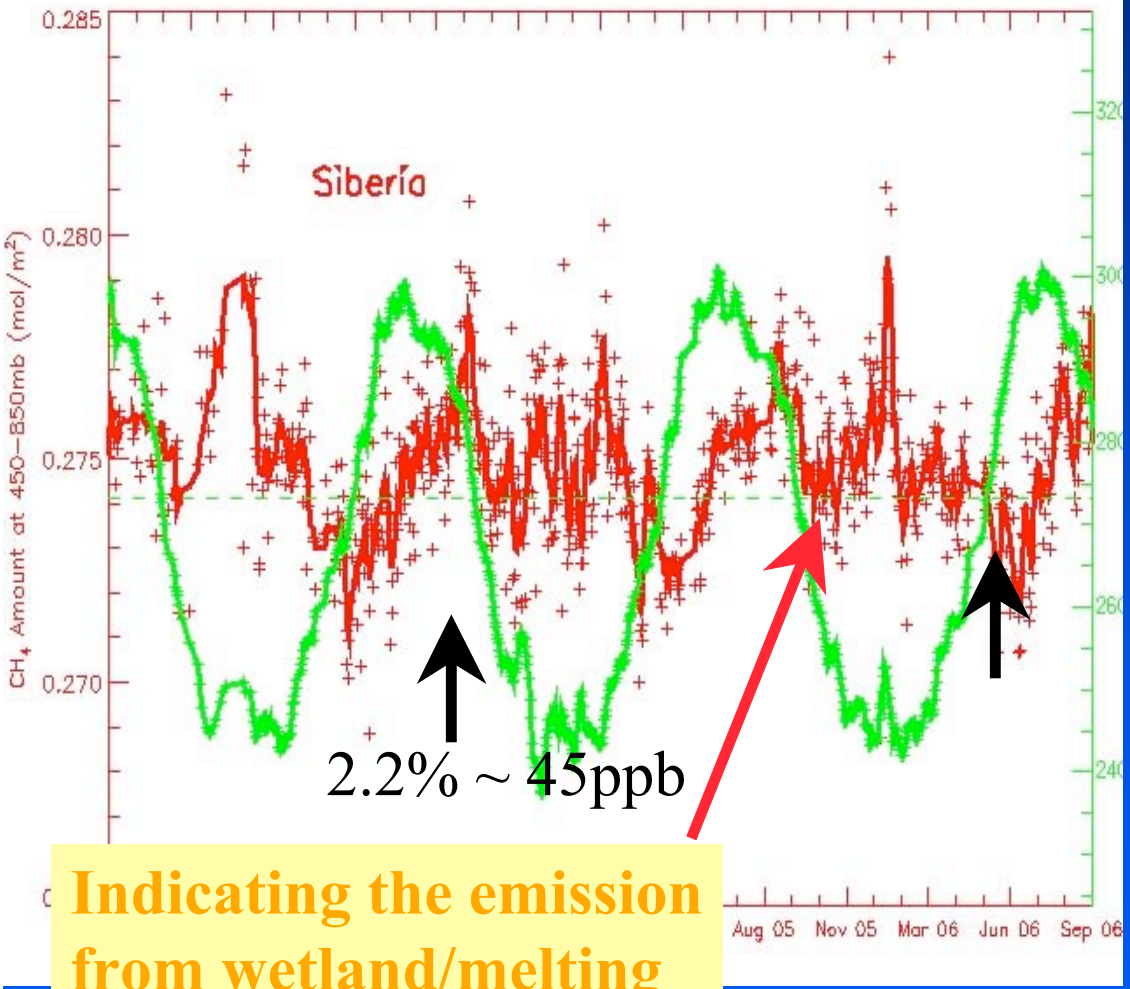
However, it is inconsistent with model and observation at MBL;

Variation of the averaging kernels makes the interpretation of AIRS retrieval compound


150–250 hpa a06xnbin_0406.ret
350–450 hpa
200
400
June
250–350 hpa
450–550 hpa
300
500
ppbv
1700 1750 1800 1850 1900 1950
150–250 hpa a06xnbin_0407.ret
350–450 hpa
July
250–350 hpa
450–550 hpa
ppbv
1700 1750 1800 1850 1900 1950
AIRS
150–250 hpa a06xnbin_0408.ret
350–450 hpa
Aug
250–350 hpa
450–550 hpa
ppbv
1700 1750 1800 1850 1900 1950
150–250 hpa a06xnbin_0409.ret
350–450 hpa
Sept
250–350 hpa
450–550 hpa
ppbv
1700 1750 1800 1850 1900 1950

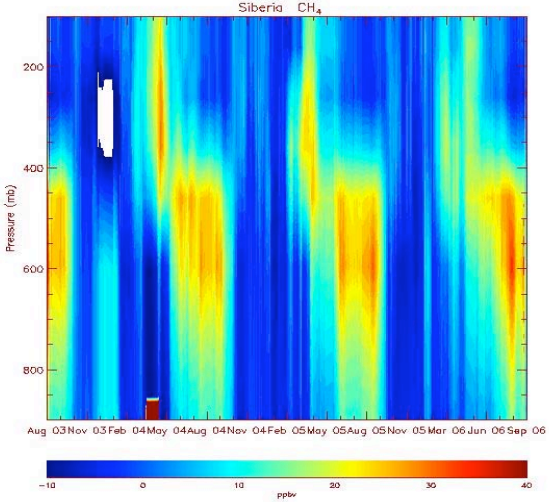

Mozart CH4 (200mb) 6
Mozart CH4 (500mb)
200
400
June
Mozart CH4 (300mb)
Mozart CH4 (750mb)
300
500
Mozart CH4 (200mb) 7
Mozart CH4 (500mb)
July
Mozart CH4 (300mb)
Mozart CH4 (750mb)
1650 1700 1750 1800 1850 1900
ppbv
MODEL
Mozart CH4 (200mb) 8
Mozart CH4 (500mb)
Aug
Mozart CH4 (300mb)
Mozart CH4 (750mb)
Mozart CH4 (200mb) 9
Mozart CH4 (500mb)
Sept
Mozart CH4 (300mb)
Mozart CH4 (750mb)
1650 1700 1750 1800 1850 1900
ppbv

Seasonal Variation of CH4 Amount in 450-850 hpa vs Surface Temperature



Indicating the emission from wetland/melting Permafrost ?

Day/Night Difference



It is hard to understand this large day/night variation:

-- partially due to the variation of averaging kernels

Cooperation with Modelers

Invited to participate in a methane working group on "*Toward an adequate quantification of CH4 emissions from land ecosystems: Integrating field and in-situ observations, satellite data, and modeling"*, at National Center for Ecological Analysis and Synthesis, Santa Barbara, CA, March 15-16, 2007.

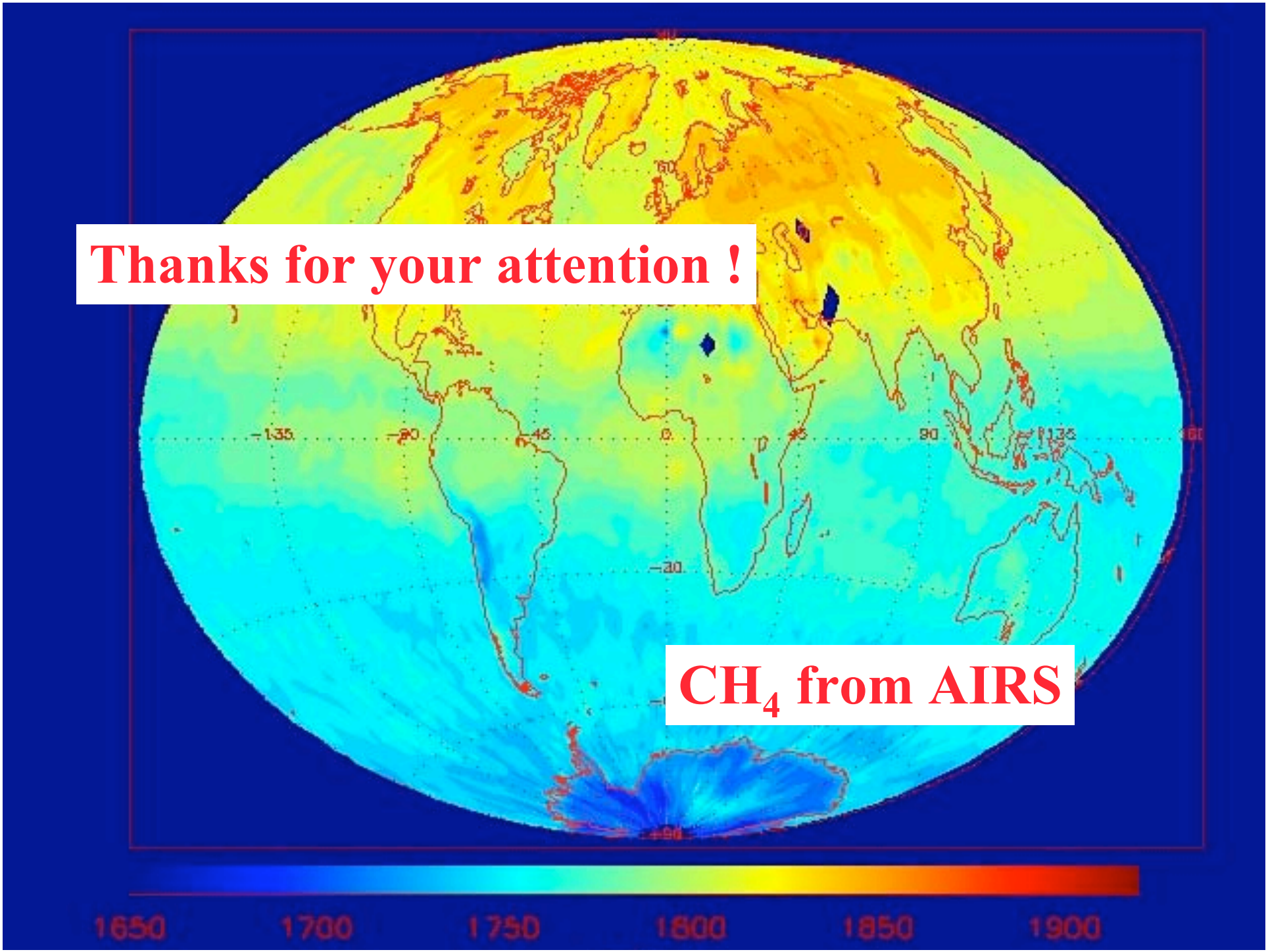
Invited to give a presentation on AIRS CH4 by Netherlands Institute for Space Research (SRON) and discussed on the cooperation to combine AIRS with model data and SCHIMACHY observation in July 2007.

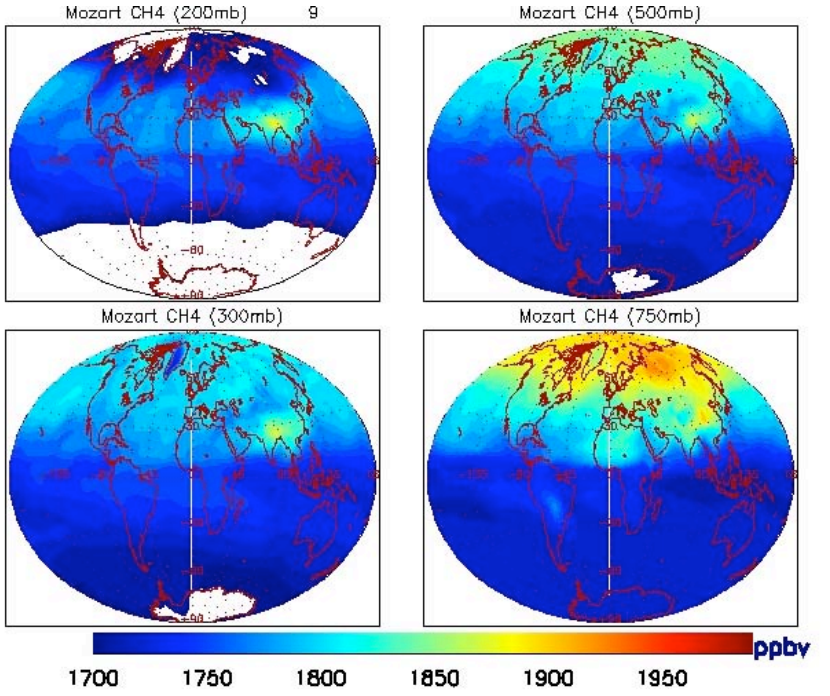
Purdue University, MIT, and SRON starts to look AIRS data.

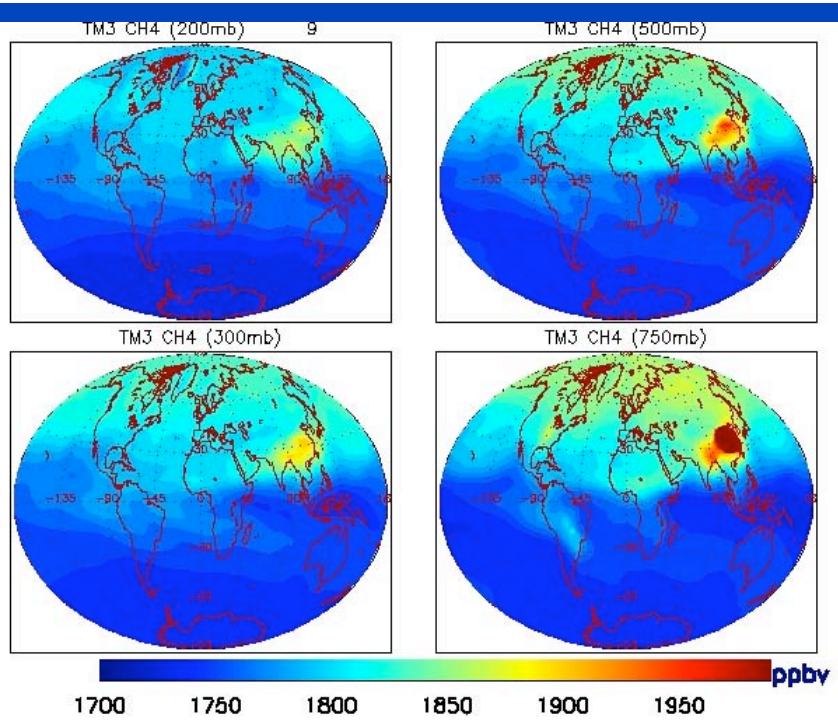
Cooperated with Chinese scientists to investigate the CH4 plume observed over the Tibetan Plateau, and its relation with Asian summer monsoon and the emission from rice paddies.

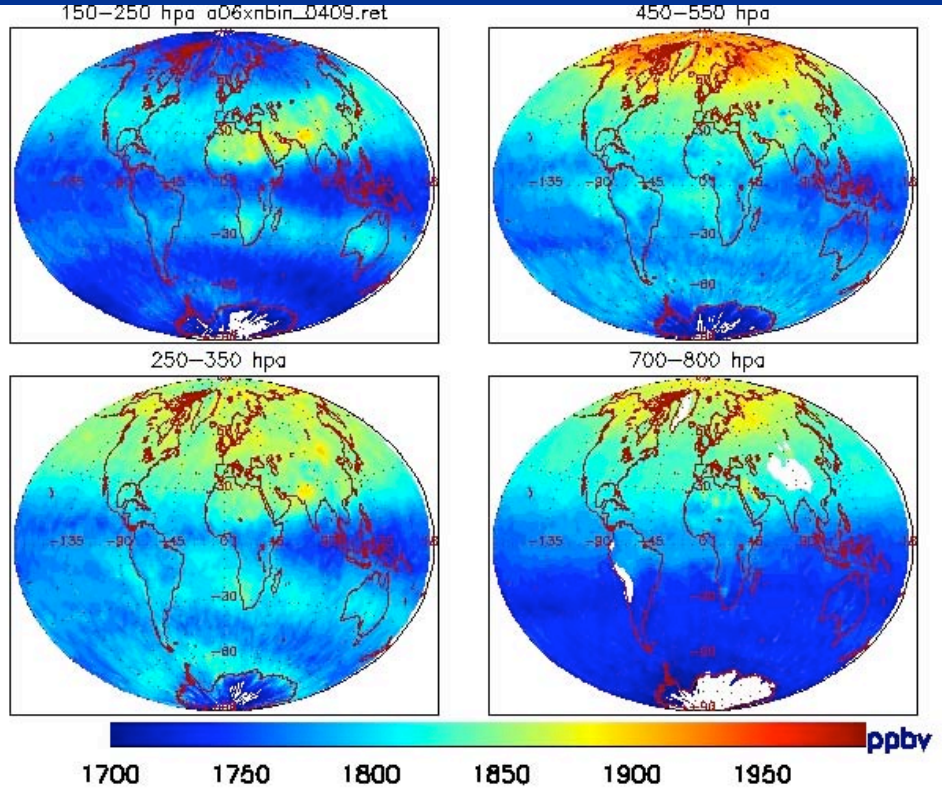
Summary

- ✓ Validations to V5 show the precision is about 1-2%;
- ✓ Something looks “odd” due to the use of CH4 amount as a predictor in the computation of water vapor absorption in current RTA, and may need to be improved.
- ✓ Re-selected channels and corresponding improvements to functions, damping have improved the retrievals;
- ✓ Observed CH_4 Plume around the Tibetan Plateau;
- ✓ Observed significant summer enhancement of CH_4 in high northern hemisphere – but inconsistent with model simulations, and need to work closely with modelers.


Thanks for your attention !
CH4 from AIRS
1650
1700
1750
1800
1850
1900


Mozart CH4 (200mb)
Mozart CH4 (500mb)
Mozart CH4 (300mb)
Mozart CH4 (750mb)
ppbv
1700
1750
1800
1850
1900
1950


TM3 CH4 (200mb)
TM3 CH4 (500mb)
TM3 CH4 (300mb)
TM3 CH4 (750mb)
ppbv
1700
1750
1800
1850
1900
1950


150–250 hpa a06xnbin_0409.ret
450–550 hpa
250–350 hpa
700–800 hpa
ppbv
1700
1750
1800
1850
1900
1950

More improvements: First-guess

V5 Model V5+